THE UTILIZATION OF CAPNOGRAPHY TO MEASURE END TIDAL CARBON DIOXIDE IN SKILLED NURSING FACILITY RESIDENTS FOR THE EARLY DETECTION OF SEPSIS TO REDUCE HOSPITALIZATIONS

A DOCTOR OF NURSING PRACTICE PROJECT SUBMITTED TO THE OFFICE OF GRADUATE EDUCATION OF THE UNIVERSITY OF HAWAI`I AT MĀNOA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

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Dedication

I dedicate this paper and project to Patrick Doyle, R.N. whose compassionate and exemplary pediatric patient care as well as his personal journey inspired me to apply my skills and knowledge to improve the quality of life and care for our kupuna here in Hawai`i.

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ASTRACT

Background

Sepsis is a significant illness in older adults. The incidence of sepsis in community dwelling older adults is 1.9% and increases to 14% among those residing in nursing facilities. Delays in diagnosis impede timely interventions and result in increased hospitalizations, complications, and deaths. Serum lactate levels have been used for early identification of sepsis in hospital settings, but collection is not possible in most prehospital settings. Capnography is non-invasive, alternative method to serum lactate for the identification of sepsis in prehospital settings which improves patient outcomes through timely interventions of fluid resuscitation and antibiotic administration. The purpose of this project was to implement an evidence-based Capnography Guideline in the skilled nursing facility population to obtain end tidal carbon dioxide levels for the early detection of sepsis in older adults to reduce hospitalizations.

Methods

A one-month pilot change utilizing a Capnography Guideline was implemented in a skilled nursing facility. Pre and post practice change data were analyzed to determine the primary outcome of reducing hospitalizations via the early detection of sepsis by capnography. Pre and post practice change data was analyzed to determine the secondary outcome of reduced hospital length of stay from early detection of sepsis by capnography.

Results

The limited SNF sample size and data supported capnography to identify sepsis. However, the small sample size of five SNF participants and the time constraints of

implementation, affected the pilot outcomes as no reduction in hospital admissions or length of stay was demonstrated.

Discussion

Capnography as a prognostic tool for utilization in Hospice referrals was an unexpected outcome presented during implementation. This outcome should be explored as it has the potential to improve palliative care in the fragile SNF population.

Further exploration with a larger SNF sample size are needed to effectively evaluate capnography and its effectiveness for the early identification of sepsis to reduce hospitalizations and length of stay for the improvement of patient care and outcomes.

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List of Abbreviations

AAFP – American Academy of Family Physicians

ACCP- American College of Chest Physicians

AMS – Altered Mental Status

AUC – Area Under the Curve

ASA – American Society of Anesthesiologists

C – Celsius

CI – Confidence Interval

CITI – Collaborative Institutional Training Initiative

CMS – The Center for Medicare and Medicaid Services

DNP – Doctor of Nursing Practice

DRG – Diagnosis Related Group

Dx - Diagnosis

EBP – Evidence-Based Practice

ED – Emergency Department

EMS – Emergency Medical Services

$ETCO_2$ – End Tidal Carbon Dioxide

ESCIM – European Society of Intensive Care Medicine

F – Fahrenheit

FSC – Functional Status Change

Hco3 - Bicarbonate

HCP – Healthcare Provider

ICU – Intensive Care Unit

IRB – Institutional Review Board

IV – Intravenous

LOS(s) – Length of Stay(s)

mmHg – Millimeters of Mercury

mmol/L – Millimoles per Liter

OA(s) – Older Adult(s)

P – Probability Value

$PaCO_2$ – Partial Pressure of Arterial Carbon Dioxide

PICO – Population, Intervention, Comparison, Outcome

PRN – As Needed

QI – Quality Improvement

qSOFA – Quick Sepsis Related Organ Failure Assessment

r – Correlation Coefficient

ROC – Receiver Operating Characteristics

SCCM – Society of Critical Care Medicine

SIRS – Systemic Inflammatory Response Syndrome

SNF(s) – Skilled Nursing Facility(s)

WOS – Web of Science

CHAPTER 1. EXECUTIVE SUMMARY

Introduction

Sepsis is a life-threatening condition resulting in over 750,000 annual hospitalizations nationwide, and accounts for 37% to 52% of hospital deaths (Ginde, Moss, Shapiro, & Schwartz, 2013; Liu et al., 2014). It is the most costly condition to treat with more than $24 billion spent annually (Sutton & Friedman, 2013). In the adult population, the probability of developing severe sepsis is five times greater in older adults (OA) than younger adults from 6.5% to 1.3% (Ginde et al., 2013). Early identification and treatment of sepsis reduces complications, length of hospital stay, and mortality (Ferrer, et al, 2014; Widmeier & Wesley, 2014).

Background/Problem

Older adults are the most susceptible population to develop sepsis in response to an existing infection (Ginde et al., 2013; Lineberry & Stein, 2014; Nasa, Juneja, & Singh, 2012). The prevalence of severe sepsis increases exponentially for OAs in skilled nursing facilities (SNF) at an incidence rate of 14% compared to community dwelling OAs at only 1.9% (Ginde et al., 2013). Delays in diagnosing sepsis impede the timely interventions of fluid resuscitation and antibiotic administration resulting increased hospitalizations, complications, and deaths (Ferrer, et al, 2014; Widmeier & Wesley, 2014).

Conceptual Framework

The Iowa Model of Evidence-Based Practice to Promote Quality of Care was chosen as the framework for this Doctor of Nursing Practice (DNP) project. This model supports the translation of knowledge into applicable practice according to the following seven steps: identification of a knowledge or problem based triggers, formation of a team, assembling the relevant literature and research, synthesis of the research and literature, pilot of practice change, institute of change in practice, and monitor and analyze the data. Details of the model are expressed in Figure 1 (Titler et al., 2001).

Literature Review & Synthesis

An exhaustive electronic search of five databases was conducted resulting in 25 relevant articles. The literature critique and synthesis supported capnography as an alternative method to identify suspected sepsis in the prehospital setting. It also identified OAs in SNFs as the population most at risk for developing sepsis.

Innovation/Objectives

Based on the evidence from the literature search and synthesis, a Capnography Guideline was developed to specifically identify suspected sepsis in OAs residing in SNFs. The objective of this evidence-based Capnography Guideline was to reduce hospitalizations through the early detection of sepsis in SNF residents via end tidal carbon dioxide ($ETCO_2$) levels.

Methods

Design (QI/EBP)

An evidence-based practice approach was utilized to translate the evidence into clinical practice decision making. The objective of this project was to implement an evidence-based Capnography Guideline in the skilled nursing facility population to obtain $ETCO_2$ levels for the early detection of sepsis in OAs to reduce hospitalizations.

Practice Change Description

There was no method for prehospital identification of sepsis employed at the SNF. Therefore, residents with suspected sepsis were transported by the emergency medical system (EMS) to the emergency department (ED) for sepsis diagnosis and treatment outside the SNF setting. These delays in diagnosis and treatment increase the risk of intensive care unit (ICU) admissions, complications, and mortality.

The new practice change of an evidence-based Capnography Guideline for the early identification of sepsis via $ETCO_2$ levels assisted healthcare providers (HCP) in the facilitation of early sepsis recognition. Early recognition enables the management of sepsis at the SNF and reduce hospitalizations. The timely administration of interventions improves patient outcomes which aligns with the mission of the HCP team and the SNF to provide innovative quality care to reduce hospitalizations and promote optimal rehabilitation.

Setting & Sample

This DNP project was implemented by the Straub Geriatric and Long Term Care Team at a 119 bed SNF on O`ahu. This facility provides transitional care for patients discharged from Straub Medical Center who require continued skilled nursing services and rehabilitation post hospitalization. The primary target population were those residents identified with sepsis by the Capnography Guideline who were under the care of Straub's Geriatric and Long Term Care Team.

Data Collection

The data sources for this project were the medical records, admission records, and discharge records of residents that meet the inclusion criteria. These sources were electronically stored in the system's database and applied to a T1-T2 evaluation. The T1 provided pre-implementation baseline data for the analysis of the T2 evaluation post implementation results. This approach was applied to determine the effectiveness of capnography for the early identification of sepsis to reduce hospital admissions and length of stay(LOS).

Results

Description of Participants

Five SNF participants met the inclusion criteria during the pilot program according to the Capnography Guideline. The SNF sample size consisted of one male and four females ranging in age from 79-92.

Medical care for the SNF participants was provided by the seven HCPs of Straub Geriatric and Long Term Care Team. Twenty-nine registered nurses provided skilled nursing care and capnometer administration at the SNF.

Data Analyses Findings

Five SNF participants were identified during the one month implementation phase. All of these participants presented with AMS and four with a RR $\geq$ 22 cpm. An $ETCO^2$ reading of <33 mmHg or < 4.4% was documented in three of the five participants. Of these three, one (age 79) was sent to ED and admitted with a diagnosis of sepsis. The other two participants were referred to hospice and had a prior diagnosis of sepsis at SNF admission.

Discussion

Interpretation of Results

The results supported capnography as a tool for the identification of sepsis. However, there were no reductions in hospital admission or length of stay.

Implications

This innovation increased the HCP's efficiency and workflow by providing a guideline to identify sepsis in the SNF. Nursing staff was empowered to utilize capnography as a vital sign for the delivery of a more comprehensive objective patient assessment to the HCP.

The limited sample size and data failed to determine whether the utilization of capnography for early sepsis identification allowed SNF residents to be treated in facility reducing hospital admissions or LOS for those requiring hospitalization.

Further programs are recommended to determine the effectiveness of capnography in the SNF setting.

Limitations

There were limitations inherent in this DNP project as the environment in which we conducted this initiative were fluid which prevented the control of variables and subjects. Implementation phase was limited to one month with two months for evaluation. The convenience sample size was small with broad inclusion criteria.

The instruments utilized to collect the data were specific to the institution and were viewed as untested instruments. Trend analysis and descriptives were utilized to evaluate the outcomes of this EBP initiative. This method of project design limited the ability to ascertain direct causality.

CHAPTER 2. PROBLEM

Introduction

Sepsis is a potentially fatal health condition impacting public health and presents an economic burden on resources (Mayr, Yende, & Angus, 2014). It is the leading cause of death in non-coronary intensive care units and the tenth most common cause of death in the United States (Sutton & Friedman, 2013; Mayr et al., 2014). At a cost of over $24 billion annually, sepsis is the most expensive condition to treat and represents nearly 25% of all hospital service charges in the United States (Sutton & Friedman, 2013).

Nationwide, over 750,000 people are hospitalized annually for sepsis (Ginde et al., 2013; Liu et al., 2014). Although this number represents only 10% of all hospitalized patients, sepsis is associated with 37% to 52% of hospital deaths according to the Journal of American Medicine. The Kaiser study reports nationwide deaths related to a diagnosis of sepsis range from 34.7% to 52% (Liu et al., 2014). Nearly 25% of all patient admissions to Straub Medical Center in Honolulu, Hawai`i, from July 2016 to April 2017 were admitted with a diagnosis related group (DRG) of septicemia or severe sepsis according to the Hawai`i Pacific Health system database.

The purpose of this Doctor of Nurse Practice (DNP) project was to implement an evidence-based Capnography Guideline in the skilled nursing facility (SNF) population to obtain end tidal carbon dioxide ($ETCO_2$) levels for the early detection of sepsis in older adults (OA) to reduce hospitalizations. This chapter reviews the background of the challenges of early sepsis recognition; the utility of capnography; depicts the literature search, critique, and synthesis; and culminates with an OA specific guideline for capnography implementation based on the evidence.

Background of Problem

In 2016, an international task force represented by the Society of Critical Care Medicine (SCCM) and the European Society of Intensive Care Medicine (ESCIM) amended the definitions of sepsis and the sepsis criteria. The evidence identified that the current definitions of sepsis results in the misinterpretation of the syndrome's progression, and the current sepsis criteria lacked sufficient sensitivity and specificity for diagnosis. The findings determined the followings recommendations to remove the term, severe sepsis, as the term sepsis represents the severity of the syndrome. The new three symptom sepsis criteria are more clinically appropriate for the rapid recognition of sepsis in the prehospital setting. These recommendations have not been fully implemented throughout the healthcare system. (Shankar-Hari, et al, 2016; Singer, et al., 2016).

Identification of suspected sepsis continues to be based on the outdated systemic inflammatory response syndrome (SIRS) diagnostic criteria previously outlined by the American College of Chest Physicians (ACCP) and the SCCM. This criteria state that the patient must have a suspected or confirmed infection and exhibit at least two of the following symptoms: fever > 38°C (100.4°F); Heart rate > 90 beats per minute; Respiratory rate > 20 breaths per minute or arterial carbon dioxide tension ($PaCO_2$) < than 32mmHg; Abnormal white blood cell count (>12,000/µL or < 4,000/µL or >10% immature [band] forms). The diagnosis of severe sepsis includes two of the SIRS criteria along with the presence of hypotension, organ failure, and hypoperfusion in one organ or more. Septic shock is diagnosed by the severe sepsis accompanied by refractory hypotension as evidenced by the failure to respond to fluid resuscitation. Hypoperfusion resulting in end-organ failure and acute cardiac failure is the distinguishing characteristic of septic shock. (Arroyo, 2016; Hunter, Silvestri, Ralls, Dean, Falk, & Papa, 2013; Widmeier & Wesley, 2014a). This outdated criterion for sepsis recognition does not consider the atypical presentation of OAs. Thus, it fails to capture this vulnerable population causing delays in diagnosis and treatment which contributes to the high rates of hospitalization and mortality (Ginde et al., 2013; Lineberry & Stein, 2014; Nasa et al., 2012).

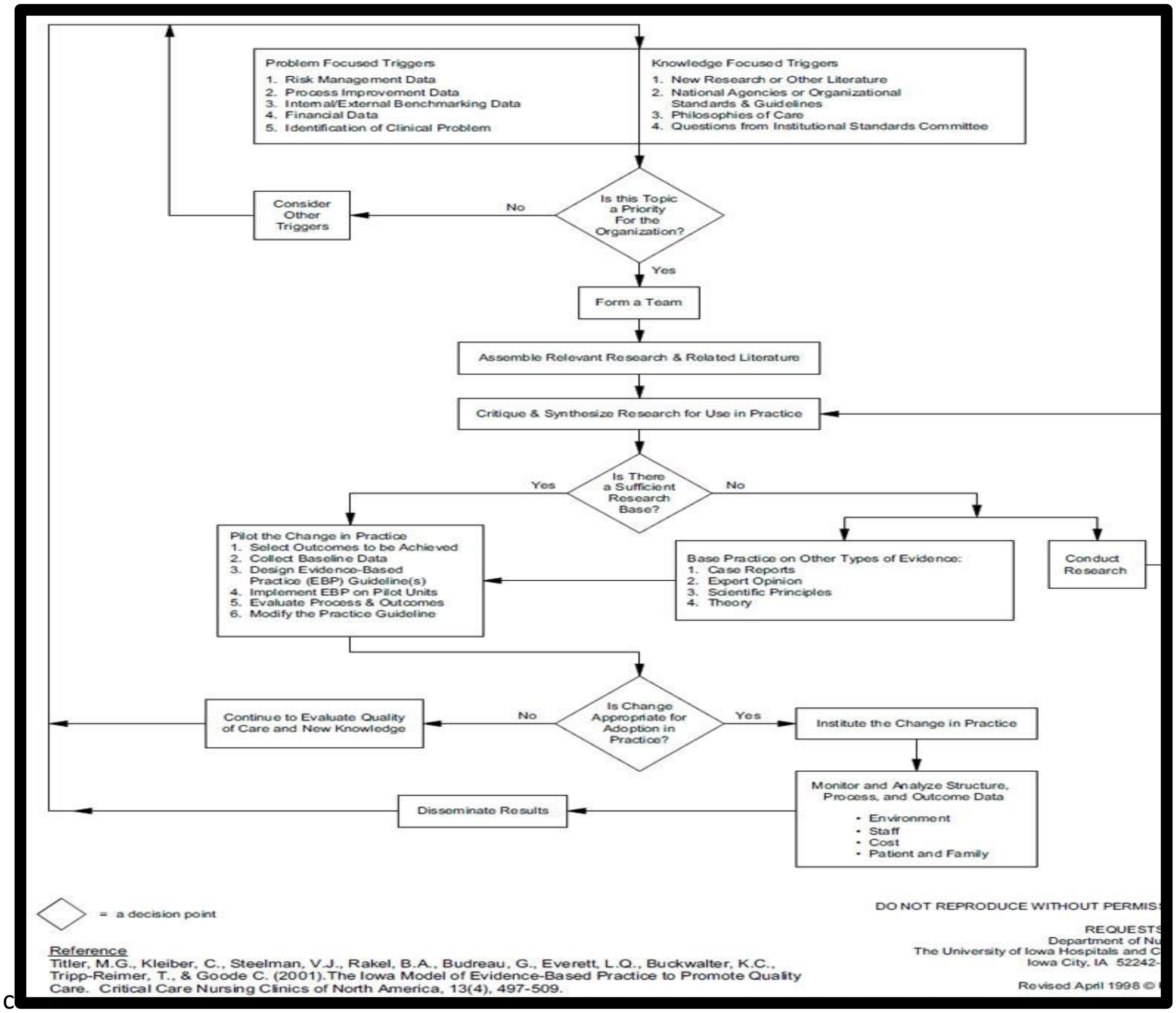
Older adults (OA), over the age of 65, comprise the majority of sepsis hospitalizations and deaths. The prevalence of severe sepsis is five times greater in OAs than younger adults from 6.5% to 1.3%. The incidence of severe sepsis in community dwelling OAs is 1.9% and increases to 14% among those residing in nursing facilities. Older adults in SNFs represent 40% of hospital intensive care units (ICU) admissions with a 7-day length of stay (LOS), and a mortality rate of 37% compared to 21% ICU admissions, 5-day LOS, and 15% mortality for community dwelling OAs. These inordinately, significant higher rates of incidence and mortality amongst the SNF population indicate the necessity to determine a more efficient method of early sepsis detection to initiate expeditious treatment for septic residents within the confines of the SNF to improve patient outcomes (Ginde et al., 2013; Lineberry & Stein, 2014; Liu et al., 2014; Nasa et al., 2012).

Conceptual Framework

The evidence-based practice (EBP) framework chosen for this DNP project was the Iowa Model of Evidence-Based Practice to Promote Quality Care as it is well reviewed, and has a successful history of implementation (Titler, et al., 2001). This model provided a structured guideline to identify the problem and develop a resolution by translating evidence into practice as detailed in Figure 1.

Figure 1

The Iowa Model of Evidence-Based Practice to Promote Quality Care



Identify Triggers

The Iowa Model begins with the identification of a problem or knowledge based trigger which is the cause for the current situation requiring an innovation (Titler et al., 2001). For this DNP project, the problem based trigger was an increase in hospital admissions of OAs with sepsis. The Hawai`i Pacific Health system's database reported the same number of adult admissions for sepsis over the past two years despite the implementation of a new hospital sepsis protocol at Straub Medical Center. The Agency for Healthcare Research and Quality's reported a 32% increase in sepsis hospital admissions from 2005-2010 (Sutton & Friedman, 2013).

The knowledge based trigger was the recent evidence supporting the utilization of capnography for early detection of sepsis along with new recommendations defining sepsis and the sepsis criteria (Guirgis et al., 2014; Widmeier & Wesley, 2014; Arroyo, 2016; Hunter et al., 2016; Lee & An, 2016; Shankar-Hari, et al, 2016; Singer, et al., 2016; Taghizadieh, Pouraghaei, Ala, Rahmani, & Sofiani, 2016).

Form a Team

A needs assessment was conducted to establish the innovation as a priority for the stakeholders. This step facilitated the forming of a team to support and implement the innovation. The team was comprised of HCPs from Straub's Geriatric and Long Term Care Team as well as the administration and nursing staff at the implementation site. Further details on the team are provided in chapter 3.

Assemble Relevant Research and Related Literature

Electronic searches of PubMed, CINAHL, Cochrane Library, and National Guidelines Clearinghouse, and The Agency for Healthcare Research and Quality website were performed using all the searches listed below. Search terms "sepsis," and "septic shock," in combination with "capnography," "end tidal CO^2," "end tidal carbon dioxide," or "end tidal capnography" resulted in 26 articles. Search limitations were 10 years and English language.

The search terms "sepsis," "immunosenescence," in combination with "older adult," or "elderly" resulted in 13 articles. Search limitations were 5 years, English language, humans, and aged. The screening criteria excluded articles related to vaccines, cancer, autoimmune diseases, and other diseases.

The terms “sepsis prevalence,” and “older adults,” in combination with “long term care,” or “nursing home*” resulted in 13 articles. Search limitations were 5 years, English language, humans, and aged. The screening criteria excluded community only dwelling older adults.

The terms “sepsis,” and “new definitions” with a search limitation of 2016-2017, English language, and humans resulted in 26 articles. This one-year parameter search was conducted to ascertain whether any new or additional sepsis definitions had been established since the 2016 Sepsis Definition Task Force guideline in 2016.

Highly relevant articles from the electronic searches were identified. A citation search utilizing Web of Science (WOS) led to an additional 11 possible articles for the literature review.

A total of 78 articles were retrieved from the search of the five databases. With the 11 articles from WOS, a total of 89 articles were reviewed. The literature synthesis consists of 25 articles that met all the criteria related to the early detection of sepsis and measuring $ETCO_2$ in patients with suspected infection in prehospital settings.

Mosby’s research critique was used to evaluate the articles and grade each article for level of evidence. The research for capnography as a screening tool for the early detection of sepsis is relatively new as evidenced by the diversity of the levels of evidence. This correlates with the EBP Framework of the Iowa Model as it seeks to utilize a variety of evidence to translate research into practice. Table 1 summarizes the levels of evidence of the articles reviewed.

Table 1

Level of Evidence

Mosby Level of Evidence	Category	Articles
Level I	**Meta-analysis, systematic review**	**2**
	Shankar-Hari et al., 2016	
	Singer et al, 2016	
Level II	**Experimental design**	**6**
	Guirgis et al., 2014	
	Hunter et al., 2013	
	Hunter et al., 2014	
	Kheng & Rahman, 2012	
	McGillicuddy et al., 2009	
	Studnek et al., 2012	
Level III	**Quasi-experimental design**	**2**
	Hunter et al., 2014	
	Taghizadieh et al., 2016	
Level IV	**Case controlled, cohort, longitudinal study**	**4**
	Ginde et al., 2013	
	Ferrer et al., 2014	
	Liu et al., 2014	
	Sutton & Friedman, 2013	
Level V	**Correlation studies**	**0**
Level VI	**Descriptive studies**	**0**
Level VII	**Authority opinion, expert committee report**	**4**
	Lee & An, 2016	
	Mouton, et al., 2001	
	Norman, 2000	
	Widmeier & Wesley, 2014	
Other	**Literature review, performance improvement**	**7**
	Arroyo, 2016	
	Englert & Ross, 2015	
	Lineberry & Stein, 2014	
	Mayr et al., 2014	
	Montoya et al., 2001	
	Nasa et al., 2012	
	Umberger et al., 2015	

Literature Review and Synthesis

Capnography measures the exhalation of carbon dioxide. This measurement, end tidal carbon dioxide, has a direct linear inverse relationship with lactate levels. As lactate levels increase, $ETCO_2$ levels decrease.

The body responds to systemic infection with an increase in cytokines triggered from the immune system. This activates the inflammatory cascade generating massive vasodilation along with a systemic vascular resistance reduction leading to hypotension.

Waste is normally eliminated through the bloodstream and released into the alveolus where it is exhaled in the form of carbon dioxide from well perfused lungs. These waste products are comprised mainly of lactic acid. The resulting deficit in proper perfusion, traps carbon dioxide and lactic acid in the body. End tidal carbon dioxide readings will be abnormally low, because the respiratory system is unable to exhale the carbon dioxide.

The correlation of lactate and $ETCO_2$ levels are also prognostic indicators of increased mortality risk. An increase in mortality is directly associated with an increase in lactate levels. End tidal carbon dioxide readings of 25 millimeters of mercury (mmHg) correlate with lactate levels up to 6 millimoles per liter (mmol/L) and is representative of this increase in mortality. The direct inverse relationship supports the inclusion of capnography in the sepsis criterion as a suitable proxy for serum lactate in the early identification of sepsis (McGillicuddy, Tang, Cataldo, Gusev, & Gusev, 2009; Hunter et al., 2013; Hunter, Silvestri, Ralls, Bright, & Papa, 2014; Widmeier & Wesley, 2014; Arroyo, 2016; Hunter et al., 2016).

Lactate

Studies from 2009 – 2016 confirmed lactate an established, sensitive biomarker for sepsis identification as well as a prognostic indicator of patient outcomes related to illness severity and mortality. An increase in serum lactate occurs in sepsis due to hypoperfusion resulting in the body's inability to clear the over production of lactate. This quantifiable, objective measure represents metabolic disturbances associated with sepsis (McGillicuddy et al, 2009; Kheng & Rahman, 2012; Hunter et al., 2013; Guirgis et al., 2014; Hunter et al., 2014; Widmeier & Wesley, 2014; Arroyo, 2016; Hunter et al., 2016; Lee & An, 2016).

Although serum lactate is a diagnostic measurement of sepsis, the delays in procuring and processing specimens negatively impacts patient outcomes. The attainment of a serum sample is invasive and requires immediate chemical processing by the laboratory. Hunter et al. (2013) revealed intervals of up to 172 minutes to obtain a serum lactate sample once a patient is triaged in the ED. These delays prolong sepsis identification and timely treatment administration which increases the risk of complications, ICU admissions, and mortality (Hunter et al., 2013; Ferrer et al., 2014; Hunter et al., 2014; Widmeier & Wesley, 2014; Arroyo, 2016; Hunter et al., 2016).

End Tidal Carbon Dioxide

Research focused on capnography as a non-invasive alternative to serum lactate levels, because of its capacity to detect hypoperfusion with immediate results. End tidal carbon dioxide has been recognized for its ability to assess perfusion, ventilation, and metabolic disturbances as evidenced by its use in the early 1990's to determine cardiac compression effectiveness, and as the American Society of Anesthesiologist's (ASA) 2010 standard of care for monitoring patients during general anesthesia and sedation (Guirgis et al., 2014; Arroyo, 2016).

Evidence over the past seven years demonstrated a direct linear inverse relationship between lactate and $ETCO_2$. Five of the six studies that measured lactate levels and $ETCO_2$ determined the existence of a significant negative correlation with coefficients ranging from -0.35 to -0.597 with a probability value of $P<.001$(McGillicuddy et al, 2009; Kheng & Rahman, 2012; Hunter et al., 2013; Hunter et al., 2014; Hunter et al., 2016). These findings substantiate that hypoperfusion and metabolic disturbances related to sepsis can be recognized by an increase in lactate levels or a decrease in $ETCO_2$ levels.

The Guirgis et al. (2014) study demonstrated a nearly significant relationship between $ETCO^2$ and lactate with a correlation coefficient of -1.90 and *P*<0.6.The following factors may provide an explanation as to why this study failed to achieve a significant correlation relationship between lactate and $ETCO_2$: sample size was too small to establish a clinical significance; two sepsis protocols in place at facility; and the inclusion of those with pre-existing pulmonary conditions may have skewed the data.

Three studies compared the relationship between $ETCO_2$ levels with the known reliability of arterial blood bicarbonate (Hco3) levels. The purpose was to determine whether capnography is an appropriate alternative to painful, time consuming arterial blood draws for the diagnosis of metabolic acidosis. The data analysis resulted in a correlation coefficient of r = 0.431 (*P*<.001) for Taghizadieh et al.'s (2016) study; r = 0.429 (*P*<.001) for Hunter et al.'s (2014) study; and r = 0.415 (*P*<.001) for Hunter et al.'s (2016) study. The findings of these studies demonstrated a significantly positive, direct linear relationship between $ETCO_2$ and Hco3 levels confirming capnography as a reliable alternative for the primary diagnosis of metabolic acidosis.

It has been demonstrated that $ETCO_2$ can predict hypoperfusion and metabolic disturbances, but what does the evidence reveal regarding capnography's efficacy to accurately and reliably identify sepsis in prehospital settings? The validity of capnography is based on its sensitivity to identify individuals with sepsis and its specificity to exclude those without sepsis. The first study to examine capnography to predict lactate reported a sensitivity of 60% and a specificity of 42% with an area under the curve (AUC) of 0.62 based on $ETCO_2$ levels of < 35 mmHg and lactate levels of > 4mmol/L (McGillicuddy et al, 2009). The most recent evidence reported by Hunter et al. (2016) demonstrated a sensitivity of 69%, a specificity of 67% with a positive predictive value of 78%, and a negative predictive value of 99% for the identification of sepsis. This study's data for identifying severe sepsis reported a sensitivity of 90%, a specificity of 58% with a positive predictive value of 47%, and a negative predictive value of 93%. The 2016 results are based on the adherence of a sepsis criteria that utilized an $ETCO_2$ of $\leq$ 25 mmHg; specific lactate levels were not noted. The AUC to predict sepsis was 0.99 and 0.80 to predict severe sepsis (Hunter et al., 2016). It is readily recognizable that as sepsis progresses, the probability of $ETCO_2$ to positively diagnose sepsis diminishes while the negative probability to exclude sepsis as a diagnosis remains relatively consistent. The sensitivity and specificity of capnography to identify sepsis makes it a practical screening tool in prehospital settings (Hunter et al., 2016).

Early identification of sepsis has been reinforced throughout the evidence to improve patient outcomes. Studnek, Artho, Garner, & Jones's (2012) study focused on whether early identification of sepsis in the prehospital setting reduces the initiation time of antibiotic administration and early goal directed therapy. The findings reported that patients who were identified by EMS with documentation of sepsis per the protocol, experienced a 52-minute decrease in antibiotic administration with a 95% confidence interval (CI) and P<.001 versus those who were unrecognized. Fifteen percent of this populous received initial antibiotic treatment in $\leq$ 1 hour as recommended by the surviving sepsis campaign guidelines. End goal directed therapy (EGDT) started 62 minutes earlier in the EMS documented sepsis populous transported with a 95% CI and P=.001 versus those unrecognized with sepsis by EMS. These decreases are attributed to the early identification of sepsis. The authors postulated that the implementation of a non-invasive prehospital screening tool that provides point of care results would substantially decrease the initiation time of antibiotics and EGDT.

Hunter et al. (2016) answered Studnek et al.'s call for a non-invasive screening tool that provides immediate results with their research on capnography to identify sepsis in prehospital settings. The findings demonstrated the capability of $ETCO_2$ to identify sepsis as an effective proxy to lactate levels based on the correlation coefficient of $r = -0.394$ ($P < .001$). Evidence further substantiated capnography's efficacy to identify sepsis with a 69% sensitivity and a 67% specificity; and severe sepsis with a 90% sensitivity and a 58% specificity.

The expert opinions of Arroyo (2016) and Widmeier & Wesley (2014) reflected their competence in emergency medicine as providers and researchers. These authors have combined their knowledge, fieldwork, and literary reviews of capnography to depict its current use in the EMS prehospital setting. Both studies conferred of the need to identify sepsis and initiate interventions in this setting as evidence supports early identification and treatment reduce complications, length of hospital stay, and mortality. Capnography is already standard EMS equipment for perfusion and ventilation assessment making it the preferred screening tool for sepsis as demonstrated by the evidence.

Several EMS systems are currently using $ETCO_2$ to identify sepsis patients and begin interventions prior to ED arrival. There is no standard EMS sepsis criteria and EMS systems have developed their own based on combined derivatives of the Robson and BAS 90-30-90 scale. As these two sepsis scales, do not include $ETCO_2$, EMS systems using capnography have devised their own sepsis criteria (Widmeier & Wesley, 2014; Arroyo, 2016). The Orange County EMS system is most noted for utilizing capnography to identify suspected sepsis due to their success as documented in Hunter et al., (2014) and Hunter et al., (2016) with an AUC of 0.99 to predict sepsis.

Notation to the limitations of capnography included certain pre-existing conditions and spontaneous versus non-spontaneous breathing. It is important to note that individuals with pulmonary diseases and those with pre-existing decreased cardiac output will exhibit abnormally low $ETCO_2$ measurements without the presence of sepsis or infection (Kheng & Rahman, 2012; Guirgis et al., 2014). In this population, $ETCO_2$ may not adequately differentiate between the individual's disease and sepsis. For SNF residents, it may be applicable to record baseline $ETCO_2$ levels upon admission for those with these pre-existing conditions to utilize for future comparison as OAs are more susceptible to sepsis (Ginde et al., 2013; Umberger, Callen, & Brown, 2015).

Although many studies measured $ETCO_2$ in spontaneous and non-spontaneous breathing individuals, capnography's utility in the prehospital setting is focused on spontaneous breathing individuals. The evidence that demonstrated the efficacy of capnography recommended its use to identify sepsis in the spontaneous breathing population (Hunter et al., 2014; Widmeier & Wesley, 2014; Arroyo, 2016; Hunter et al., 2016; Taghizadieh et al., 2016).

Atypical Presentation of Older Adults

Being of older age is a risk factor for sepsis and is attributed to normal signs of aging which alters the body's innate and adaptive ability to fight off infection (Nasa et al., 2012; Lineberry & Stein, 2014; Englert & Ross, 2015; Umberger et al., 2015). Immunosenescence is a progressive decline in the functional ability of the aging immune system to recognize and effectively eliminate antigens that infiltrate the body (Nasa et al., 2012; Englert & Ross, 2015). This is associated with the aging body's diminished thermoregulatory response to infection preventing the common febrile response in this population. Therefore, the standard definition of fever as of 100.4^0 Fahrenheit (F) or 37^0 Celsius (C), is not an accurate indication of early infection in the OA. Older adults may exhibit a delayed or absent febrile response despite the presence of infection. Fevers of 100.4^0 F or 37^0 C in this population is a late sign associated with severe infection and increased mortality (Norman, 2000; Mouton, Bazaldua, Pierce, & Espino, 2001; Montoya, Cassone, & Mody, 2016).

The American Academy of Family Physicians (AAFP) and Lineberry & Stein (2014) stated to properly assess infection in the OA, a fever should be defined as 1.1^0C or 2^0 F greater their baseline (Mouton et al., 2001). Evidence from a study by Norman (2000) amongst nursing home residents demonstrated a temperature of 37.2^0 C or 99^0 F has an 83% sensitivity and an 89% specificity indicative of a febrile response to infection. Although specificity and sensitivity were greater at higher temperatures, the study surmised that a febrile response in OAs be recognized at 37.2^0 C or 99^0 F, or 1.3^0 C above a patient's baseline for the early identification of infection (Norman, 2000). Montoya, Cassone, & Mody (2016) defined fever in the OA populous as 1.5^0 C or 2.4^0 F from baseline temperature. Although, there are slight variations, all agreed that fever in OAs is blunted and present at lower temperatures than the adult populous (Norman, 2000; Mouton et al., 2001; Lineberry & Stein, 2014; Montoya et al., 2016). It is determined that a higher temperature in OAs indicates severe, potentially fatal infection; thus, delaying interventions until presentation of higher temperatures increases complications, hospital admissions, and the mortality rate for OAs (Norman, 2000; Mouton et al., 2001; Lineberry & Stein, 2014).

Immunosenescence also affects the adaptive immune response to infection. Leukocytosis as it relates to sepsis is an elevation in white blood cells due to the inflammatory response representative of infection. As the body ages, the functional changes in T-cells reduces the number of white blood cells that can adequately respond to infection (Nasa et al., 2012; Lineberry & Stein, 2014; Mouton et al., 2001; Englert & Ross, 2015; Umberger et al., 2015). Englert & Ross (2015) and the AAFP reported that 40% of OAs will not exhibit an increase in white blood cells in the presence of infection (Mouton et al., 2001). This blunted response does not rule out the absence of infection in OAs. Therefore, leukocytosis is not a reliable marker of infection in OAs (Mouton et al., 2001; Englert & Ross, 2015).

Older adults have a propensity to exhibit nonspecific responses to infection due to normal process of aging, polypharmacy, and comorbidities. The single most common response is altered mental status. Older adults may express changes in mentation by confusion, restlessness, agitation, withdrawal, delirium, and changes in speech associated with active infection. Changes in functional abilities related to activities of daily living may be a signal of suspected infection. Falls are often associated with infection as changes in mentation or function may contribute to impaired decision making or balance issues (Nasa et al., 2012; Lineberry & Stein, 2014; Mouton et al., 2001; Englert & Ross, 2015; Umberger et al., 2015).

Malaise is another common nonspecific symptom of infection in the elderly. This symptom is exhibited by generalized weakness, discomfort, or uneasiness of which the patient cannot identify the source. Lethargy and decrease in appetite may be nonverbal signs of malaise (Nasa et al., 2012; Lineberry & Stein, 2014; Mouton et al., 2001; Englert & Ross, 2015; Umberger et al., 2015).

Current sepsis criteria are unsuitable in the prehospital setting, because they are too broad or they fail to adequately address the atypical presentation of OAs. By neglecting to recognize the subtle symptoms and absent signs of infection within the OA population causes delays in early sepsis identification. The negative impact of delayed diagnosis impedes the timely administration of intervention leading to an increase in hospital admissions, complications, and deaths (Ginde et al., 2013; Umberger et al., 2015)

Common Sites of Infection

Common sites of infection present in OAs with sepsis are respiratory, genitourinary, abdominal, and skin (Mayr et al., 2014). Pneumonia is the most frequent site of infection and accounts for 50% of sepsis hospital admissions (Englert & Ross, 2015;). Mortality is highest with respiratory infections (Mayr et al., 2014). Older adults comprise 75-82% of patients admitted for pneumonia associated sepsis (Umberger et al., 2015). The second most frequent site is genitourinary with urinary tract infections (Nasa et al., 2012). Sepsis related infections are more inclined to be caused by gram negative bacteria of *Pseudomonas* species, *Escherichia* coli, or *Klebsiella* species. When the infection is caused by gram positive bacteria, *Staphylococcus* aureus is most frequently noted. Although it is recommended that blood cultures be obtained to identify the bacteria causing the infection, 50% of infections associated with sepsis are unable to be determined (Lineberry & Stein, 2014). Mayr et al. (2014) concurs with Lineberry & Stein (2014), albeit the authors stated that 33% of blood cultures do not obtain a positive result in severe sepsis cases. This supports the initial administration of empiric antibiotics to treat sepsis (Nasa et al., 2012; Ferrer et al., 2014; Lineberry & Stein, 2014).

New Sepsis Definitions

The SCCM and the ESICM combined an international task force that redefined sepsis and the sepsis criteria in 2016. The new definition of sepsis is a potentially fatal organ dysfunction cause by an impaired regulatory response to infection. New parameters redefined the SIRS criteria as it was considered to have poor discriminative validity and patients without sepsis can present with the same symptoms. The new criteria for out of hospital identification of sepsis is altered mental status < 15 on the Glasgow Coma Scale, SBP < 100 mmHg, and respiration rate > 22 cycles per minute. This new criterion is representative of the quick Sepsis Related Organ Failure Assessment (qSOFA). Data analysis demonstrated an increase in sensitivity for prehospital settings predictive validity with an AUC ROC of 0.81 and a 95% CI (Lee & An, 2016; Shankar-Hari et al., 2016; Singer et al., 2016).

The only symptom of sepsis identification noted above that is attributable to the atypical presentation of OAs is altered mental status (AMS). Since this population does not exhibit vital sign changes in early infection, blood pressure and respiration abnormalities may be late signs. Therefore, the new streamlined criteria may still fail to capture the most vulnerable population at the most critical point for aggressive interventions to reduce hospital admissions, complications, and mortality (Mouton et al., 2001; Nasa et al., 2012; Lineberry & Stein, 2014; Englert & Ross, 2015; Umberger et al., 2015).

Septic shock is defined as an element of sepsis whereby severe anomalies in cardiovascular and metabolic pathways significantly raise the risk of mortality. The detection of septic shock is more easily identifiable by the new parameters of refractory hypotension post fluid resuscitation demanding vasopressor management to retain a mean arterial pressure (MAP) of > 65 mmHg or a serum lactate level of > 2 mmol/L. Mean arterial pressure is determined by doubling the diastolic blood pressure and adding this sum to the systolic blood pressure. This calculation is divided by three. The remaining sum is the MAP (Lee & An, 2016; Shankar-Hari et al., 2016; Singer et al., 2016).

Evidence demonstrated, lactate as a prognostic indicator of illness severity in sepsis and correlates with mortality risks as lactate levels rise (Hunter et al., 2014). This compelled the task force to redefine the parameters of lactate associated with septic shock and mortality. Previously a lactate level of > 4 mmol/l indicated septic shock and now that number has been reduced to > 2 mmol/L. The mortality rate is >40% in patients who require vasopressors to maintain a MAP > 65 mmHg or > 2 mmol/L of lactate (Lee & An, 2016; Shankar-Hari et al., 2016; Singer et al., 2016).

Body of Evidence

There was a strong, well rounded body of evidence supporting capnography as a reliable and valid prescreening tool for the identification of early sepsis. The data supported the sensitivity and specificity of capnography to identify sepsis as well as $ETCO_2$'s direct inverse relationship with the recognized biomarker of lactate, and the positive correlation between $ETCO_2$ and Hco3 to recognize metabolic disturbances (McGillicuddy et al., 2009; Kheng & Rahman, 2012; Hunter et al., 2013; Guirgis et al., 2014; Hunter et al., 2014; Widmeier & Wesley, 2014; Arroyo, 2016; Hunter et al., 2016; Taghizadieh et al., 2016). The evidence was limited as the preponderance of research, exhausted by the literature search, was conducted in the last five years. Although this is relatively new research, the data from the ten studies remained consistent in its evidence of lactate, and the utility of capnography to identify early sepsis in prehospital settings.

The authors of the studies related to the atypical presentation and management of OAs with sepsis, are unified that OAs present with nonspecific symptoms of infection due to the normal aging process (Norman, 2000; Mouton et al., 2001; Nasa et al., 2012; Ferrer et al., 2014; Lineberry & Stein, 2014; Mayr et al., 2014; Englert & Ross, 2015; Umberger et al, 2015; Montoya et al., 2016). Their evidence supported the necessity of an OA sepsis guideline to capture this unique and vulnerable population as the current SIRS criteria is too broad and fails to address their atypical presentation of suspected infection.

Innovation/Objectives

Implications for Practice

Currently, serum lactate levels are unattainable in the prehospital setting of SNFs. Therefore, when residents exhibit symptoms of suspected infection and sepsis, the resident is transported to the ED via the EMS system. This causes added delays in fluid resuscitation and antibiotic administration increasing the risk of hospitalization, complications, and mortality. Ferrer et al. (2014) reported that for every hour antibiotic therapy is delayed, the risk of death increased; the risk of death was 24.6% during the first hour of antibiotic administration and rose nearly 10% to 33.1% at the sixth hour in the absence of antibiotic administration. Studies showed that empiric antibiotic administration within the first hour of suspected sepsis, improved patient outcomes and decreased the mortality risk (Ferrer et al., 2014; Lineberry & Stein, 2014; Widmeier & Wesley, 2014; Umberger et al., 2015).

The utilization of capnography reduced the delays in identifying sepsis by providing immediate results at the point of care. Studies supported capnography as a reliable, non-invasive alternative method to serum lactate based on the direct inverse correlation between $ETCO_2$ and serum lactate as well as its sensitivity and specificity to appropriately identify sepsis. The supposition of the evidence supports the implementation of capnography will enable residents to remain at the SNF and receive timely administration of aggressive treatment for sepsis to reduce hospitalizations, complications, and mortality (Hunter et al., 2013; Hunter et al., 2014; Widmeier & Wesley, 2014; Arroyo, 2016; Hunter et al., 2016).

It is important to note that pre-existing conditions of pulmonary diseases and decreased cardiac output exhibit abnormally low $ETCO_2$ measurements in the absence of infection. A consideration for those SNF residents is to conduct capnography upon admission to determine a baseline $ETCO_2$ level for comparison should the resident develop an infection (Kheng & Rahman, 2012).

The evidence demonstrated the importance of an appropriate sepsis criteria to identify symptoms of sepsis in the prehospital setting. Despite the new definitions of sepsis and symptom criteria, it remained too broad to effectively capture the atypical presentation of the OA population. The development of an OA specific Capnography Guideline for SNF residents postulates to reduce hospital admissions and decrease the length of hospital stay by empowering HCPs to identify early sepsis for the initiation of aggressive interventions in prehospital settings. The objective of this DNP project was to translate the research evidence into practice from the prehospital EMS setting to the prehospital setting of the SNF to reduce hospitalizations and manage sepsis within the facility by utilizing $ETCO_2$ levels as a proxy for lactate levels for early detection (Norman, 2000; Mouton et al., 2001; McGillicuddy et al., 2009; Kheng & Rahman, 2012; Nasa at al., 2012; Hunter et al., 2013; Guirgis et al., 2014; Hunter et al., 2014; Lineberry & Stein, 2014; Widmeier & Wesley, 2014; Englert & Ross, 2015; Umberger et al., 2015; Arroyo, 2016; Hunter et al., 2016).

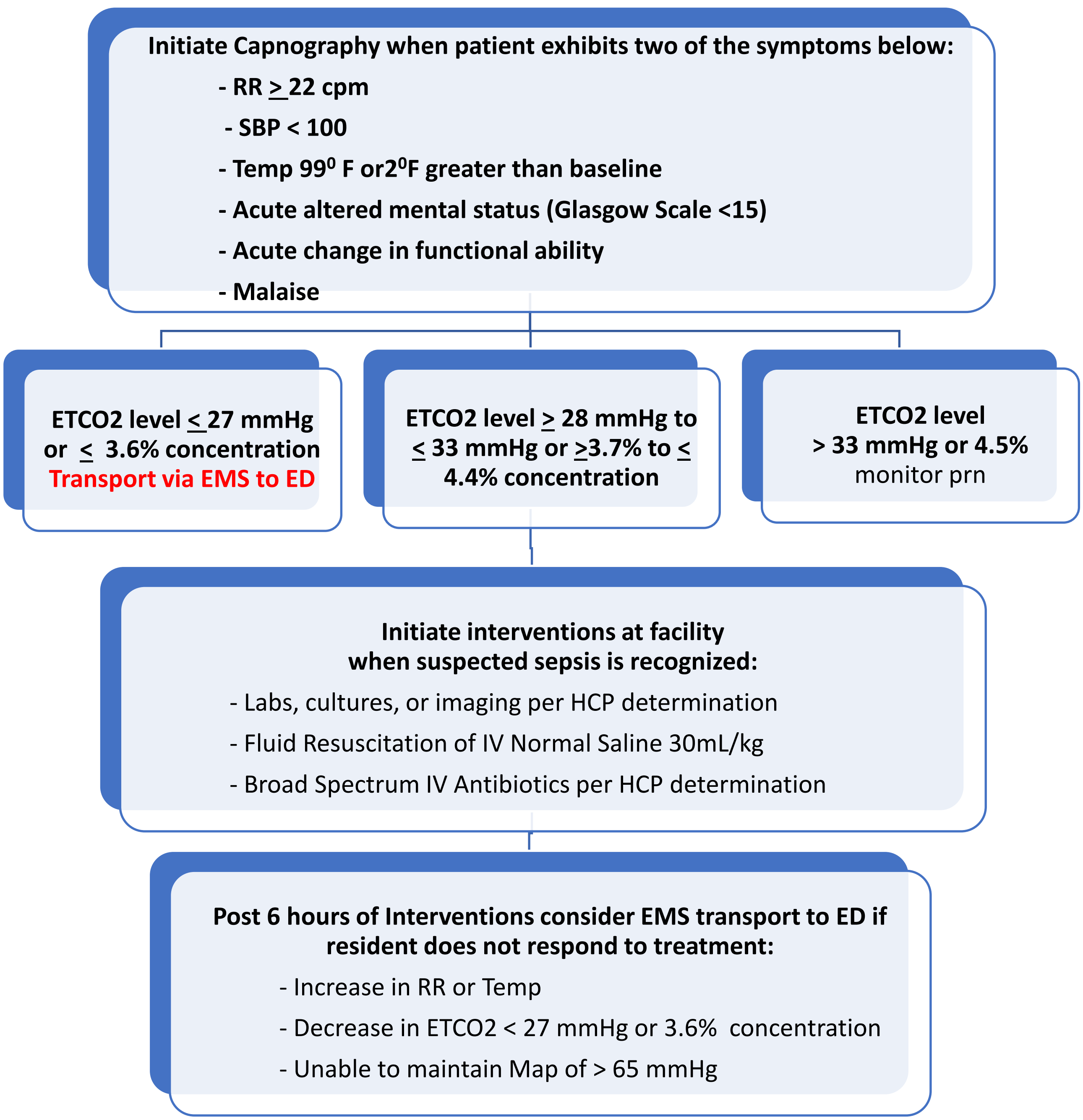
Capnography Guideline

This innovation utilized an evidence-based Capnography Guideline for the early detection of sepsis in SNF residents to reduce hospitalizations as outlined in Figure 2. The guideline includes SIRS criteria that was modified for the atypical presentation of infection in older adults.

Figure 2

Capnography Guideline for the Early Identification and Management of Sepsis in Older Adults Residing in Skilled Nursing Facilities

Capnography Guideline with Modified SIRS Criteria



The Capnography Guideline for the early identification and management of sepsis in OAs residing in SNFs begins with criteria to identify suspected infection and implement capnography. This guideline is based on the evidence of $ETCO_2$, atypical presentation of OAs, and the 2016 sepsis parameters from the SCCM and the ESCIM. Three of the six symptoms are the variables represented in the quick sepsis related organ failure assessment qSOFA score expressed by the SCCM and the ESCIM task force; respiration rate of > 22 cycles per minute (cpm), SBP < 100, and Glasgow Scale of < 15 (Shankar-Hari et al., 2016; Singer et al., 2016). As the single most common response to infection in OAs is a change in mentation, the inclusion of AMS in the new sepsis parameters assist in capturing this nonspecific OA presentation. The scoring allows for one change on the scale for positive inclusion of suspected infection and sepsis.

To establish a more specific criterion for OAs, acute functional ability alterations, malaise, and defined temperature ranges are incorporated to more effectively identify early sepsis in this population. The three additions are based on common atypical presentation of infection per the research evidence. Their inclusion will assist in capturing more SNF residents in the early stages of sepsis where complications and mortality can be greatly reduced by aggressive administration of fluid resuscitation and empiric antibiotic administration (Norman, 2000; Mouton et al., 2001; Nasa et al., 2012; Ferrer et al., 2014; Lineberry & Stein, 2014; Mayr et al., 2014; Englert & Ross, 2015; Umberger et al., 2015; Montoya et al., 2016).

The Capnography Guideline's range of $ETCO_2$ levels for sepsis identification and transport to the ED is based on the research of Kheng & Rahman, (2012) and Hunter et al. (2013) To garner an accurate reading with the capnometer, the test administrator should record the measurement post 3-5 respiration cycles as evidenced by the wave pattern on the capnograph display monitor (Hunter et al., 2013; Hunter et al., 2014; Hunter et al., 2016). When resident presents with 2 or more symptoms according to the guideline with an $ETCO_2$ level $\geq$ 28 mmHg or $\leq$ 33 mmHg sepsis is identified. Intravenous (IV) fluid resuscitation and broad-spectrum IV antibiotics administration should begin within an hour to improve patient outcomes and reduce mortality (Ferrer et al., 2014). If the $ETCO_2$ level falls below 28 mmHg at any time, consider transport to ED for emergent care as the mortality rate increases as the $ETCO_2$ levels decrease (Kheng & Rahman, 2012; Hunter et al., 2013; Widmeier & Wesley, 2014).

At the post 6-hour mark of fluid resuscitation and antibiotic administration, if the resident remains stable or improves, treatment continues at the SNF. Should at the post 6-hour mark, the resident fails to respond to treatment as evidenced by an increase in RR or temperature, or a decrease in $ETCO_2$ level or SBP, the HCP should consider transport by EMS to the ED for emergent care to preserve life (Kheng & Rahman, 2012; Hunter et al., 2013; Widmeier & Wesley, 2014).

The objective of this Capnography Guideline is to readily identify sepsis in OAs and provide expeditious treatment at the SNF to reduce hospitalizations. Evidence demonstrated that early sepsis identification along with administration of antibiotics and fluid resuscitation within one hour of sepsis recognition, decreased complications, reduced hospital LOSs, and improved patient outcomes (Studnek et al., 2012; Ferrer et al., 2014; Widmeier & Wesley 2014; Hunter, et al., 2016; Arroyo, 2016).

Summary

The purpose of this DNP project was to implement an evidence-based Capnography Guideline in the skilled nursing facility population to obtain $ETCO_2$ levels for the early detection of sepsis in OAs to reduce hospitalizations. The exhaustive literature search, critique, and synthesis produced evidence of the utility of capnography to measure $ETCO_2$ for the early identification of sepsis. Older adults over the age of 65, comprise the majority of sepsis hospitalizations and deaths with an exponential increased prevalence of sepsis in SNFs residents of 14% compared to 1.9% for OAs not residing in SNFs (Ginde et al., 2013). Further discussion of the methods to pilot the practice change and evaluate the Capnography Guideline are addressed in the following chapter.

CHAPTER 3. METHODS

Objectives

This Doctor of Nursing Practice (DNP) project employed The Iowa Model of Evidence-Based Practice as its implementation framework. The DNP project site supported the utilization of this established model for its successful history of translating evidence-based knowledge into sustainable practice change. When promoting practice changes, this model considers a holistic view of the healthcare system from the provider, patient, and the organization's infrastructure. In this chapter, the implementation framework focused on steps five through seven to pilot the change in practice, institute the practice change as well as monitor, analyze the structure, process, and outcome data (Titler et al., 2001).

The formulation of the clinical question for this DNP project utilizes the population, intervention, comparison, and outcome (PICO) statement. The results of the PICO are defined as follows:

P-Patient Population: Older Adults (OA) residing in skilled nursing facilities (SNF) with suspected sepsis

I-Intervention: Implementation of an evidence-based Capnography Guideline

C-Comparison: Current practice of transporting suspected sepsis residents to the emergency department (ED) via the emergency medical system (EMS)

O-Outcomes: Reduce hospitalizations by expediting sepsis recognition and treatment of sepsis at the SNF.

The DNP project was based on this clinical question: Will the implementation of capnography reduce hospitalizations for sepsis among older adults residing in SNFs?

The elements of the clinical question were based on the following:

a) Would an evidence-based sepsis criteria and guideline for the implementation of capnography specific to OAs reduce hospitalization for those residing in SNFs?

b) What metrics would provide optimal measurements to best evaluate the outcomes of the project?

The objective of this DNP project was to implement an evidence-based Capnography Guideline in the skilled nursing facility population to obtain end tidal carbon dioxide ($ETCO_2$) levels for the early detection of sepsis in OAs to reduce hospitalizations. This early identification will reduce hospitalizations by facilitating expeditious treatment at the SNF within the recommended one hour of sepsis recognition.

Design (QI/EBP)

Quality improvement (QI) projects focus on processes to improve the quality of patient care. These projects are site specific and do not require extensive literature reviews and synthesis for systematic implementation.

Research is a systematic process whereby new knowledge is generated. Evidence-based practice (EBP) translates research into application. This DNP project utilized an EBP design as an exhaustive literature search and critique of the evidence has been conducted to translate the research into clinical practice decision making. The objective of this project was to provide a Capnography Guideline to assist healthcare providers in the early identification of sepsis in OAs residing in SNFs.

Practice Change Description

This DNP project aligned with the priority of the HCP team and the SNF organization as the purpose of the innovation is to reduce hospitalizations by utilizing an evidence-based Capnography Guideline for early identification of sepsis in this OA population. The plan to sustain the practice change began with the demonstration of capnography's relative advantage and compatibility to the stakeholders as it upholds and improves their mission statement to provide innovative quality care to reduce hospitalization and promote optimal rehabilitation.

Current Practice

A change in health status was first noted and assessed with increased respirations, fever of $\geq$100.4, decrease in blood pressure, and/or generalized discomfort. The vital signs and assessment were recorded in the resident's medical records. These signs represent suspected infection in OAs, and may indicate sepsis in SNF residents. Without a proxy for serum lactate to identify sepsis in OAs at the SNF, the current practice was to transport suspected sepsis residents via EMS to the ED. Thus, further delaying the time of initial treatment and increased cost to care. Residents identified with sepsis were admitted to the hospital for treatment. All documentation of vital signs, assessment, and orders were recorded in the resident's medical records.

New Practice

Under the new practice change, early subtle symptoms of sepsis were recognized by the nursing staff with the aid of the Capnography Guideline. This guideline led the nursing staff to initiate capnography for those residents who met the sepsis criteria. Capnography was performed along with the resident's vital signs. The nursing staff notified the healthcare provider (HCP) of the $ETCO_2$ level along with the vital signs and resident's accompanying symptoms. Healthcare providers assessed the resident and utilized the Capnography Guideline to verify early sepsis with the $ETCO_2$ level. Then according to the recommendations of the guideline, the HCP initiated treatment at the SNF or recommended transfer to ED for further evaluation. This early recognition reduced the time to treatment. All documentation of vital signs, assessment, and orders were recorded in the resident's medical records.

Anticipated Impact of New Practice

This evidence-based Capnography Guideline for OAs residing in SNFs was anticipated to impact the HCPs, residents, and the nursing staff. This new practice guideline changed the current practice of transporting suspected sepsis residents to the ED via EMS by providing for the early identification of sepsis and treatment at the facility. Healthcare providers required education on the current evidence-based practice Capnography Guideline. There was no resistance to the change in practice by the HCPs, as the team has previously identified a need in practice change for the identification of sepsis. This innovation was projected to increase the HCP's efficiency and workflow providing an accurate, evidence-based Capnography Guideline to identify early sepsis. The consistent utilization of the guideline was projected to readily identify sepsis in this population and result in a reduction of hospitalizations for the treatment of sepsis. This practice change was postulated to improve care and patient outcomes by decreasing the time to treatment administration.

The nursing staff was impacted with learning and applying the new technology. Capnography was user friendly and provided a wave pattern and numerical measurement displayed on the hand-held device. These displays provided a gauge for the user to ensure proper implementation and accuracy of readings. The feasibility of capnography along with interactive demonstrations relieved any trepidation by the users. There was little impact to the nursing staff's daily workflow as capnography was incorporated into the routine vital signs for those residents who met the sepsis criteria of the Capnography Guideline. The easy to follow guideline for OAs was be displayed at the nurse's station and their individual work stations.

The anticipated impact upon the resident was the improvement of patient outcomes from rapid identification of early sepsis. This early identification enabled time sensitive treatment within the facility or rapid transport to the ED. Early treatment reduces hospitalizations, complications, and hospital length of stay (LOS) (Ferrer et al., 2014; Lineberry & Stein, 2014; Widmeier & Wesley, 2014; Umberger et al., 2015).

Who, What, Where, When, How

The practice change impacted the HCPs of the Straub Geriatric and Long Term Care Team, the SNF nursing staff, and the SNF residents under the care of the Straub Team. This innovation addressed how sepsis is identified and managed by providing a means of early detection and treatment within the SNF. The impact of the practice change affected the sample population at the SNF implementation site from December 14, 2017 to January 14, 2018. It was postulated that the Capnography Guideline decreased workflow and increased efficiency for the HCPs; it empowered the nursing staff to objectively assess the residents for sepsis; and reduced hospitalizations for the SNF residents.

Relative Advantage

The mission of the Straub Geriatric and Long Term Care Team and the SNF was to reduce recurrent hospitalizations through the delivery of innovative quality patient care to enhance optimal recovery. Capnography delivered relative advantage to the healthcare providers (HCP), organization, staff, and residents by providing a source by which early sepsis can be detected within the SNF for the expeditious management of sepsis resulting in a reduction in hospitalizations. Thus, enabling the resident to remain at the SNF and receive time sensitive, appropriate treatment to reduce complications and mortality. This was advantageous over the current practice of transporting residents to the ED which delayed treatment leading to increased risk of complications and mortality (Ferrer et al., 2014; Lineberry & Stein, 2014; Widmeier & Wesley, 2014; Umberger et al., 2015).

Compatibility

Capnography was compatible with the innovation users as it integrated seamlessly with the administration of vital signs. For those residents who satisfy the sepsis criteria of the Capnography Guideline, the measurement of $ETCO_2$ was added to their vital sign requirements. The hand-held capnometer was performed in 3-5 respiratory cycles via the attached nasal cannula. From initiation to $ETCO_2$ results were less than 60 seconds. This innovation was not a burden on the user's workflow. Capnography was a non-invasive tool that is user and resident friendly.

Complexity

To perform capnography, the user needed only to attach the nasal cannula to the resident and ensure the tubing is properly connected to the capnometer. With the press of a button, the capnometer displayed a wave pattern on the device and the $ETCO_2$ numerical measurement. The wave pattern allowed the user to identify the 3-5 respiration cycles required to ascertain appropriate $ETCO_2$ levels. Innovation users are often uneasy about new technology and the degree of difficulty to master its function. Capnography matched well with vital signs as its administration, function, and degree of difficult is similar to the tools used to ascertain these routine measurements. This knowledge put the innovation users at ease and instilled confidence in their ability to perform capnography.

Trialability

Through team meetings, demonstrations of capnography was provided and all members had the opportunity to operate the capnometer. Any questions or concerns were immediately addressed which reduced inaccurate assumptions regarding the innovation. By promoting the technology and dispelling the trepidation, adoption of the innovation increased.

Observability

Capnography was readily observable as the hand-held capnometer provided an immediate result on the display monitor with a wave pattern and the numerical measurement. The wave pattern provided a gauge for the user to determine that the appropriate respiratory cycles were performed to achieve an optimal reading. User awareness was also enhanced by the knowledge that this technology was standard practice in diverse settings within the healthcare industry. By increasing the user's awareness of the technology, the rate of adoption of the innovation was simultaneously increased.

Plan for sustainment

The plan to sustain the practice change begins with an innovation that resolves a problem which the stakeholders view as a priority to improve quality of care and practice. Capnography resolved the problem of identifying sepsis at the SNF and allowed the opportunity to provide expeditious treatment at the facility when appropriate. The innovation users recognized the impact of this tool and its relative advantage. It was the responsibility of the innovation leader to identify the strengths, weaknesses, and limitations results obtained from the evaluation. Ease and efficacy of the innovation's implementation influenced the adoption of the practice change as part of the everyday processes and practice of the culture within the facility. The continuance of the innovation was promoted by incorporating training of capnography in the organization's standard employee education.

Definitions

Definitions increase the specificity with which data is collected and analyzed. This DNP project utilized a T1-T2 design to answer the clinical question: Will the implementation of capnography reduce hospitalizations for OAs residing in SNFs?

Operational Definition

Capnography is the measurement of $ETCO_2$ and has a direct inverse relationship with the known biomarker for sepsis, lactate. As the lactate level increases, the $ETCO_2$ level decreases as hypoperfusion prevents the exhaled release of carbon dioxide. When the level of $ETCO_2$ falls below the normal range of 35-45 mmHg, it is an indication of metabolic disturbances associated with infection and sepsis. This drop in $ETCO_2$ correlates with an abnormal increase in lactate from its normal range of 0.5-1.0 mmol/L. Early identification of sepsis in prehospital settings can be determined by capnography.

An evidence-based Capnography Guideline specific to OAs was developed to address the atypical presentation of infection. This resource focused on vital sign alterations and subtle, non-classic symptoms of infections prevalent in OAs. The tool directed the user regarding capnography initiation and followed through with sepsis management in the SNF. This evidence-based resource tool guided the HCP in the recognition and management of sepsis in OAs.

This DNP project focused on those SNF residents identified with sepsis via capnography. The primary measure of the DNP innovation was the number of residents admitted to the hospital with a diagnosis of sepsis. This project's secondary measure was the hospital LOS required for sepsis treatment. All data was recorded in the resident's electronic health records.

Baseline Definition

T1 baseline data will be established for the two separate measures. The primary measure was the number of sepsis hospital admissions and the secondary measure was the hospital length of stay required for treatment. Baseline data was collected before the innovation was implemented. The primary baseline definition was the number of hospital admissions from the SNF to Straub Medical Center for sepsis from December 2016 to January 2017. The secondary baseline definition was the number of hospitalized days required for the treatment of these SNF residents diagnosed with sepsis at Straub Medical Center from December 2016 to January 2017.

Innovation Definition

The innovation was the evidence-based implementation of capnography to identify early sepsis in OAs residing in SNF. This innovation was operationalized via an evidence-based Capnography Guideline specific to the atypical presentation of OAs as seen in Figure 2.

Outcome Definition

The outcome's primary T2 operational definition was the number of hospital admissions from the SNF to Straub Medical Center for sepsis from December 2017 to January 2018. The outcome's secondary T2 definition was the number of hospitalized days required for the treatment of SNF residents with sepsis at Straub Medical Center from December 2017 to January 2018. Outcome data was collected and counted after the implementation phase was completed.

Sampling Plan

Setting

This DNP project was implemented with the Geriatric and Long Term Care Provider Team from Straub Medical Center. This team provided continuum of care for patients discharged from the hospital and transitioning into a SNF. The DNP project was conducted at a 119 bed SNF on O`ahu.

Sample

The primary target population were the HCPs represented by Straub's Geriatric and Long Term Care Team. This team provided transitional medical care for the SNF residents who were discharged from Straub Medical Center. The accessible population were the HCPs on the Straub Geriatric Team assigned to the SNF.

The secondary target population focused on SNF residents were discharged from Straub Medical Center. Residents who were identified with sepsis via capnography comprised the accessible population at the SNF.

Sample size. The primary accessible sample of HCPs that provided care to the residents at the SNF was seven; three assigned to the facility and four additional HCPs addressed after hours concerns. These HCPs managed the care of residents throughout the facility and were not assigned to a unit. The HCPs provided transitional care for SNF residents discharged from Straub Medical Center who required skilled nursing services and rehabilitation before returning to residential housing or long term care facilities.

The secondary accessible sample were the 29 registered nurses trained to administer capnography. Nursing staff identified the Straub Team SNF participants based on the Capnography Guidelines.

Residents who were discharged from Straub Medical Center and were identified with sepsis via capnography over the one-month implementation phase comprised the receiving participants of the accessible sample. These residents were not set apart from the other residents in a single unit, but rather were interspersed throughout the units of the facility.

Inclusion criteria. Inclusion criteria for the HCPs were those members of the Straub Geriatric Team assigned to oversee the transitional care of the residents discharged from Straub Medical Center. The HCPs participating in this project agreed to utilize the evidence-based Capnography Guideline to identify sepsis in residents with suspected infection.

Inclusion criteria for SNF residents consisted of SNF residents admitted to Straub Medical Center for sepsis from December 2016 to January 2017 for the pre-implementation inclusion criteria. Resident inclusion criteria during the implementation phase requires the identification of sepsis via capnography at the SNF from December 2017 to January 2018.

Exclusion criteria. Those HCPs at the SNF who did not manage the care of residents that have been discharged from Straub Medical Center were excluded from this DNP project.

Skilled nursing facility residents with sepsis who were not discharged from Straub Medical Center were not be included in the relevant sample. The SNF residents whose HCP was not a member of the Straub Geriatric Team were excluded from the implementation phase. Nursing staff and HCPs who did not provide care for the relevant sample were excluded from the DNP project.

Recruitment plan. A needs assessment was conducted to ensure that the proposed project change provided relative advantage for the stakeholders. This approach took into consideration the utility, feasibility, propriety, and accuracy of the project’s processes of innovation implementation, data collection, and evaluation methods. By addressing the stakeholders in this manner, unity was achieved as a team to focus on the implementation of a capnography to identify early sepsis in SNF residents.

The stakeholders each played a role in the change process. These roles consist of, but are not limited to, project authorization, credibility, change advocacy, implementation, data collection, and evaluation. The roles of the stakeholders are further defined in Table 2.

It is important to note that the beneficiaries of the innovation are stakeholders in the project. The stakeholders were the SNF residents who met the inclusion criteria and were recognized as the relevant sample, the Straub HCPs, and the SNF nursing staff.

Table 2

Team Members

Stakeholder	Category	Role
Facility Administrator (SNF)	Program Operations User of Eval Findings	Increase credibility of evaluation plan Fund/authorize actions to implement
Director of Nursing (SNF)	Program Operations User of Eval Findings	Increase credibility of evaluation plan Assist with design of evaluation plan User of evaluation findings
Content Advisor (Straub Team HCP)	Program Operations User of Eval Findings	Advocate for changes to implement Assist with design of evaluation plan Increase credibility of evaluation plan
Change Champion (Lead Straub HCP)	Program Operations User of Eval Findings	Advocate for changes to implement Increase credibility of evaluation plan Implement the intervention
Charge Nurse (SNF)	Program Operations User of Eval Findings	Advocate for changes to implement Increase credibility of evaluation plan Implement the intervention
Facility Nursing Staff and Straub Team HCPs	Users of Eval Findings	Implement the intervention Data Collection
DNP Student	Lead Innovation	Education of innovation Collect data and evaluate findings

Data Collection Procedures

The data management plan provided a transparent strategy whereby the stakeholder was confident that the data sources, data collection, and data analysis plan supplied credible data that accurately answered the evaluation question. To ensure the reliability of the results, the evaluator sought out the stakeholder's expertise in the SNF setting to develop the data management plan for this DNP project.

The data quality of this evaluation was supported in several ways. This organization was recognized as producing quality data, because it met the data documentation, collection and analysis requirements of the SNF industry as required by The Center for Medicare and Medicaid Services (CMS). With this in mind, the stakeholder team acknowledged that data sources already routinely used by the facility were credible sources for this DNP project's data management plan. These data sources were medical records, admission records, and discharge records which were stored electronically in the system's database. The data from these sources were accurate, because staff was familiar with this form of documentation and their collection procedures. Data quality was protected, because continuing education was provided for the nursing staff by the facility to retain appropriate objective documentation.

Chronological Order of Data Collection Procedures

The evaluation had three data sources which are listed below with their data elements and additional explanation.

- Admission Records included two data elements: Date of admission to the SNF and admitting diagnosis. Admission records were electronically established for each patient admitted to the SNF post hospitalization by the unit supervisor. These records included the resident's hospital diagnosis, hospital LOS, treatments, prognosis, and medical history. This data was required to establish inclusion criteria of sepsis diagnosis and length of hospitalization at Straub Medical Center from December 2016 to January 2017. The collection of this data was gathered prior to the implementation phase for the T1 baseline measurement.

- Medical Records included one data element: Sepsis diagnosis. Medical record data was electronically established for each patient by the unit supervisor upon admission to the SNF. These records were updated as needed by HCPs, rehabilitation staff, unit supervisor, and the nursing staff.
- Discharge Records include two data elements: Date of discharge from SNF to Straub Medical Center and admitting hospital diagnosis. Discharge records were electronically established for each patient discharged from the facility. These records included the date of discharge, condition of resident upon discharge, where the resident was discharged to, and how the resident was transported upon discharge from the SNF.

The same data sources were utilized to gather post implementation data for the T2 outcome measurement. One change was noted as two data elements will be collected from the medical records: sepsis diagnosis and $ETCO_2$ levels. These data sources and collection procedures provided the data required for the program evaluation plan.

Required Resources

Below were the resource considerations for the implementation of this DNP project. Each one was addressed to ensure the success of the innovation.

Financial. A financial proposal was submitted and initially approved by Straub Medical Center to cover the cost to purchase the capnometer and $ETCO_2$ cannulas for the implementation phase of this project. However, the compliance department was concerned with potential complications related to the Starke Law as the Straub Team would be allowing the equipment to be utilized by the SNF nursing personnel. After several months without a resolution, the compliance department agreed that there was no conflict of interest if the equipment was purchased by the DNP innovator. The DNP innovator supplied all printed material necessary for project implementation education and dissemination.

Human. The human resources to complete each phase of the change process were secured: Straub Medical Center Geriatric and Long Term Care providers assigned to the SNF, facility administrator, director of nursing at the SNF, and the facility nursing staff. A further breakdown of the roles is displayed in Table 2.

Time. Three months of the proposed implantation phase were absorbed by the compliance issues related to the equipment purchase. Therefore, the implementation phase was revised and limited to one month to meet completion deadlines. The facility provided consent for the implementation process to be conducted at their location by the Straub Geriatric Team and the DNP innovator from December 2017 to January 2018. Stakeholders agreed to the revised proposed DNP timetable.

Physical. The facility provided access to computers, workspace to conduct evaluations, and conference room space for formal and informal meetings related to staff education, stakeholder meetings and presentations. The SNF authorized the physical implementation phase of the innovation to be conducted on their premises according to the DNP timetable.

Process & Outcome Variables

The process variable was the adherence to the Capnography Guideline. Residents who met the criteria triggered the implementation of capnography to identify sepsis. Perception of nursing staff to the subtle, atypical presentation of infection in OAs may impact the adherence of the criteria which determines the implementation of capnography. There could be a decrease in sample size or increase in sample size that affects the results of the evaluation data. This potential variable was addressed with interactive demonstrations of the Capnography Guideline along with visual displays at the facility to promote awareness as indicated in Figure 4.

The primary outcome variable was an increase or decrease in Straub Medical Center admission from this SNF for residents with a diagnosis of sepsis recognized by capnography. Exacerbation of comorbidities, adverse reaction or failure to respond to interventions, and patient preference to defer hospitalization despite the deterioration in health status are variables that affect the data for the primary outcome of hospitalizations. These variables may not be controlled and can impact the data and results of the implementation phase.

The secondary outcome variable was an increase or decrease in the LOS for residents from this SNF receiving treatment for sepsis at Straub Medical Center. Complications, comorbidities, and mortalities are variables that can impact the resident's LOS that may be unrelated to the sepsis diagnosis. These variables have the potential to impact the data and results of the innovation.

Measurements

The early identification of sepsis was measured by $ETCO_2$ via capnography. An $ETCO_2$ level $\geq$ 28 mmHg or $\leq$ 33 mmHg was recognized as sepsis in residents who meet the criteria of the guideline. Residents with an $ETCO_2$ measurement in this range were to be treated at the facility. Residents with an $ETCO_2$ measurement $\geq$ 27 mmHg were to be sent to the ED for emergent evaluation.

The innovation was evaluated on the primary outcome a decrease or increase in hospitalizations based on the early detection of sepsis via capnography. The secondary outcome of the innovation was evaluated on the decrease or increase in hospital LOS for residents recognized to be septic by $ETCO_2$ levels measured by capnography.

Timeline

The proposed timeline for this DNP project spanned eleven months beginning with chapters 1-3 submission and ending with the final defense. Below in Figure 3 is a detailed timeline that outlines the steps and timeframe of the change process.

Figure 3

DNP Project Timeline

Task	2017							2018			
	J	J	A	S	O	N	D	J	F	M	A
Chapter 1-3 Submission to Chair 6/11/17											
Chapter 1-3 Submission to Committee											
Present Proposal Defense 8/1/ 2017											
Development of Educational and Marketing Systems											
Baseline Data Collection											
Stakeholder /Staff Educational Sessions											
Initiate Pilot Practice Change											
Pilot Change Implementation											
Data Collection											
Data Evaluation											
Present Results to Innovation Users											
Dissemination of Results											
Final Defense 3/28/2018											

Program Evaluation Plan

Data Analysis

The data analysis plan was organized around two phases: pre-implementation (T1) and post implementation (T2). The number of SNF residents hospitalized and the LOS for those residents admitted to Straub Medical Center from December 2016 to January 2017 with the diagnosis of sepsis. Collection of this data from medical, admission, and discharge records occurred during the pre-implementation phase. This data provided the T1 baseline measurement for the evaluation's primary outcome of SNF residents hospitalized for sepsis and the secondary outcome of LOS for the treatment of sepsis.

Data was collected from the same sources at post implementation (T2) for December 2017 to January 2018. The T1 and T2 results for SNF resident admissions to Straub Medical Center for sepsis was analyzed to determine whether the innovation reduced the number of hospitalizations for residents that were identified with sepsis via capnography. T1 and T2 results for LOS for those residents admitted for sepsis was analyzed to determine whether early identification of sepsis via capnography reduced their LOS for the treatment of sepsis.

Analysis of the data was conducted by the stakeholders and the evaluator. The expertise of the stakeholders ensured the appropriate interpretation analysis of the data. Stakeholder participation increased the credibility of the findings.

Data Presentation Plan

The initial target audience for the dissemination of the project results was the Straub Geriatric and Long Term Care, facility administrator, and SNF director of nursing, and the SNF nursing staff who participated in the project. All stakeholders were provided an electronic copy of the evaluation results.

The data presentation plan focused on the results of the evaluation in relation to the primary and secondary outcomes to reduce hospitalizations and LOS. Identification of the strengths, weaknesses, and limitations of the project will be reported. After the stakeholders have reviewed the evaluation results, the DNP innovator reviewed the Capnography Guideline with the users to gain their feedback on its utility and feasibility. This discussion strengthened and refined the practice change as needed.

The plan to sustain the practice change began with the demonstration of capnography's relative advantage and compatibility to the stakeholders as it upheld and improved their mission statements to provide innovative quality care to reduce hospitalization and promote optimal rehabilitation. This practice change not only supported the mission statement, it also provided financial benefits to the organizations by reducing the opportunity days related to sepsis hospitalizations. As the cost benefit greatly outweighs the minimal cost of supplies to maintain the practice change, capnography enhances financial feasibility. The ease and efficacy of this practice change as it is seamlessly incorporated into the routine vital signs, supports its sustainment within the organization and the culture. With incorporation of capnography as part of new employee training, the practice change may remain effective.

Human Subjects of Considerations

This DNP project proposal was constructed to preserve the rights of all human participants. The following defines this DNP project as it relates to the consideration of human subjects:

- There was no randomization of participants to different treatments.
- This project implemented evidence-based practices.
- This DNP project practice change posed no risk beyond the standard practices of care.
- No identifiers that would distinguish the participant's identity were published.
- The author of this DNP project completed the Collaborative Institutional Training Initiative (CITI) course in Human Subjects Protection as required by University of Hawai`i.

- To ensure the provision of adequate human subject protection, this DNP proposal was reviewed by a committee comprised of faculty and clinical experts.

Justification to Exclude the Institutional Review Board Process

Institutional Review Board (IRB) approval was not required for this DNP project as it is not a research study. The DNP project was reviewed by Straub Medical Center who designated the DNP project as a quality improvement project to improve patient care. This quality improvement initiative employed evidence-based practices to ensure that ethical tenets were invoked.

Limitations

There were limitations inherent in this DNP project as the environment in which the pilot was conducted is fluid. In such an environment, the variables and subjects were not controlled. Time constraints allowed for an implementation phase of one month with two months for evaluation and final project completion process of four months. The convenience sample size of five SNF was small with broad inclusion criteria.

The instruments utilized to collect the data were specific to the institution and were viewed as untested instruments. These instruments were used by this healthcare system with good success. Although the nursing staff was educated in objective documentation, there remains a margin for subjectivity. Implementation practices were provided to minimize errors and bias in data collection. Trend analysis and descriptives were utilized to evaluate the outcomes of this quality improvement initiative. This method of project design limits the ability to ascertain direct causality.

Summary

This chapter established the methods by which the evidence-based utilization of capnography to identify sepsis in the prehospital setting translates into application according to the evidence-based framework provided by the Iowa model (Titler et al., 2001). To implement this innovation into practice the following was taken into consideration: resources were allocated; outcomes were determined; data collection methods established; and program evaluation of the practice change defined as well as its impact on the innovation users and the recipients of the innovation. Together these processes comprised the plan outlined in this chapter that conducted this evidence-based DNP project's utilization of capnography for the early identification of sepsis in SNF residents. Following the evidence-based framework, the next chapter will discuss the project's evaluation of post implementation data.

CHAPTER 4. RESULTS

Objectives

The objective of the pilot implementation was to utilize capnography for early identification of sepsis in SNF patients to reduce hospital admissions and reduce hospitalized length of stay. This evidence-based initiative's intent was to enhance innovative quality care.

Description of Sample

Straub Geriatric and Long Term Care Team

The Straub Team was comprised of three medical doctors and four nurse practitioners. Primary care of SNF patients at the SNF implementation site was provided by one medical doctor and two nurse practitioners. As after hours calls are distributed amongst the Straub Team, all seven healthcare providers completed training on the utilization of the Capnography Guideline with electronic and hard copies at their disposal.

SNF Nursing Staff

The SNF nursing staff was comprised of 29 Registered Nurses; one Director of Nursing, three unit managers, one unit supervisor, and 24 floor nurses. All nursing staff members were trained on the application and operation of the capnometer as well as symptom identification to initiate its use. A hard copy of the instructions was provided to every nursing staff member as demonstrated in Figure 4. The instructions were posted at the nurse's stations, the medication room where the capnometer was stored, and on each medication cart.

Figure 4

Capnography Utilization Instructions for SNF Nursing Staff

Nursing Instructions to Utilize Capnography

Identify 2 Patient Symptoms

RR $\geq$ 22
SBP $<$ 100
Temp 99^0 or $>$
Altered Mental Status
Change in Functional Status
Malaise

Begin Capnography

1.Attach Capnography Nasal Cannula to top of capnometer
2.Place capnography nasal cannula on patient
3.Turn on capnometer with orange button
4. Silence alarm by pressing center button next to orange
4.Record ETCO^2 level after 5 or more wave consistent graphs
Retain Nasal Cannula at patient bedside for future use

Call Straub MD/NP

when ETCO^2 level is **$\leq$ 33mmHg or $\leq$ 4.4%**

If **$\geq$ 34mmHg or $\geq$ 4.5%** and symptoms persist, monitor prn

SNF Patients

Patients that had been discharged from Straub Medical Center and admitted into the SNF site during the implementation phase from December 2017 to January 2018. The patient implementation sample consisted of 5 patients that exhibited symptomology according to the the Capnography Guideline.

In the previous year, from December 2016 to January 2017, two patients met the inclusion criteria. Those two patients were discharged from Straub to the SNF with a diagnosis of severe sepsis and septic shock.

Trend Analysis

No similarities were identified from pre-implementation baseline data regarding SIRS symptoms between the two participants. However, both participants had been discharged from Straub Medical Center to the SNF with a diagnosis of sepsis; one diagnosis of severe sepsis and the other diagnosis of septic shock. These two participants were both readmitted for hospitalization under their discharge diagnoses as stated above.

Post implementation data demonstrated significant similarities in SIRS symptomatology between the 5 participants related to AMS and RR; 80% of participants exhibited a RR $\geq$ 22 and 100% scored < 15 on the Glasgow scale for AMS.

In accordance with the evidence research on capnography, when the ETCO^2 reading was 4.5% or $\geq$ 33 mmHg no diagnosis of sepsis was identified. This was demonstrated and supported by the ETCO^2 levels of the 2 participants whose levels were > 4.4% and not diagnosed with sepsis.

Figure 5

Pre and Post Implementation Trends

	RR $\geq$ 22	**SBP<100**	**Temp 99^0**	**AMS**	**FSC**	**Malaise**	**ETCO^2 < 33 mmHg or <4.4%**	**Sepsis Dx**
T1	1	1		1	1	1	*N/A	2
T2	4	1	1	5	2	2	3	1

*N/A denotes not applicable as capnography not utilized during pre-implementation phase.

Evolution of Project

Expected versus Actual Outcomes

Blood Pressure. It was expected that theT2 participants with suspected sepsis would exhibit a decrease in SBP <100 according to the new sepsis definitions and criteria (Shankar-Hari et al., 2016; Singer et al., 2016). In actuality, one of the five T2 participants exhibited this symptom. This unexpected outcome was attributed to the evidence that stated blood pressure was a delayed response for infection in this population (Mouton et al., 2001; Nasa et al., 2012; Lineberry & Stein, 2014; Englert & Ross, 2015; Umberger et al., 2015).

The T2 participant (age 92) that did present with SBPs < 100 and a normal ETCO^2 levels was sent to the ED. This patient was diagnosed with hyponatremia which accounted for the hypotensive episodes.

Direct causality of the one T1 participant's SBP < 100 could not be determined. However, considerations included low SBP as a late sign along with the outdated SIRS criteria that was in place with no modified criteria specifically for OAs.

Altered Mental Status. Altered mental status was an expected and actual outcome exhibited by 100% of the T2 participants and one of the two T1 participants. Research evidence compiled for this project, identified AMS as the first and most common symptomatic infectious response amongst OAs; this was also evidenced in the addition of AMS with a Glasgow scale < 15 added to the new sepsis definitions and criteria (Mouton et al., 2001; Nasa et al., 2012; Lineberry & Stein, 2014; Englert & Ross, 2015; Shankar-Hari et al., 2016; Singer et al., 2016; Umberger et al., 2015). The nursing staff were not required to document cognitive changes in the T1 participants, because AMS was not included in the outdated SIRS criteria utilized at that time and due to possible misinterpretation of cognition changes attributed to aging.

ETCO^2. There were no ETCO^2 measurements for the T1 participants as capnography was not available during the baseline pre-implementation phase.

The outcomes of the ETCO^2 results during the implementation phase were expected and unexpected as reflected in the Capnography Guidelines and noted on Figure 6. One of the three SNF patients (age 79) admitted to the facility with a discharge diagnosis of sepsis presented with an ETCO^2 level $\leq$ 3.6% or $\leq$27 mmHg. In accordance with the Guideline and the HCP's assessment, the patient was sent to the ED, readmitted, and treated for sepsis.

Another T2 participant (age 92) demonstrated nearly normal $ETCO^2$ levels that per the guideline are to be monitored prn and treated if appropriate. Patient was transported to the ED per patient request and in accordance with the HCP's assessment of the patient; patient had history of hypotension. At ED patient was diagnosed and treated for hyponatremia.

With an $ETCO^2$ level between $\geq$3.7-4.4% or $\geq$ 28-32 mmHg, another T2 participant (age 88) was treated at the SNF per the Capnography Guideline. This patient was not septic, but experiencing shortness of breath.

Unexpected Outcome. Two of the three T2 participants (age 77 and 86) admitted to the SNF with a diagnosis of sepsis, presented with $ETCO^2$ levels between 1.2-3.4% or $\leq$ 27 mmHg. Although the Capnography Guideline recommended sending the patients to the ED, patient and family consulted with the HCP. A hospice referral was initiated; the patients died 3 and 4 days post hospice consultation.

The pilot project found hospice referral as an unanticipated consequence of capnography. This unexpected outcome is supported by the evidence from Kheng & Rahman, (2012) to transfer patients with $ETCO^2$ levels $\leq$ 12 mmHg into Hospice care as mortality is imminent. Data from the same study demonstrated that ED patients, who at any time during a two hour period, presented with an $ETCO^2$ levels $\leq$ 12 mmHg or $\leq$ 1.6% failed to survive to hospital admission. With $ETCO^2$ levels $\leq$ 28 mmHg or $\leq$ 2.3%, the mortality rate was 55% (Kheng & Raman, 2012).

The HCPs were able to utilize $ETCO^2$ levels when making hospice referrals to SNF participants and their families. The additional information capnography provided was found to aid the decision-making process of hospice care for participants and their families.

Figure 6

$ETCO^2$ levels and outcomes of T2 participants

Age	Gender	$ETCO^2$	Treatment	Current Dx	Admit Dx to SNF	Results
79	Male	26-27 mmHg /3.4-3.6%	Sent ED	Sepsis	Sepsis	Discharged
92	Female	34-39 mmHg/4.5-5.1%	Sent ED	Hyponatremia	Fall s/p Hypotension	Discharged
88	Female	29-33 mmHg/3.8-4.3%	Treat at SNF	SOB	Stroke s/p Resp Failure	Discharged
77	Female	11-27 mmHg/1.5-3.5%	Hospice Referral	Hospice	Sepsis	Death
86	Female	9-26 mmHg/1.2-3.4%	Hospice Referral	Hospice	Sepsis	Death

Hospital Admissions. The primary expected outcome was a decrease in hospital admissions as capnography would be a proxy for lactate in the SNF population. The T1, baseline data, documented two SNF patients transported to ED and treated for sepsis from December 2016 to January 2017. The T2 data from the implementation phase documented one SNF patient a(age 79) identified with an $ETCO^2$ level $\leq$ 3.6% or $\leq$27 mmHg requiring transport to ED in accordance with the Capnography Guideline. The patient was admitted and treated for sepsis; this is a readmission for sepsis. There were no other T2 participants diagnosed with sepsis during the implementation phase. Therefore, the data from this project failed to meet the expected outcome, as the actual outcomes demonstrated no change in hospital admissions for sepsis despite the capnography intervention.

There was no opportunity to provide treatment at the facility for the T2 participant stated above (age 79). This SNF patient was the first to be evaluated with capnography on the day of implementation initiation. The patient's medical condition required immediate transport to the ED. However, capnography aided the decision of the HCP to treat the SNF patient with one intramuscular dose of antibiotic prior to ED transport. This patient had been admitted to the SNF with a diagnosis of sepsis. No other T2 participants were diagnosed with sepsis.

Hospital Length of Stay. A secondary expected outcome was a reduction in the hospitalized length of stay for SNF resident with a sepsis diagnosis. The T1 baseline data demonstrated that two SNF residents were readmitted and treated for sepsis. Both T1 participants were hospitalized for three days. The one T2 participant (age 79) readmitted to the hospital for sepsis had a 10 day length of stay. The analyzed data demonstrates that the project failed to reduce the length of stay for sepsis despite the intervention of capnography. As stated above, this T2 participant was identified with suspected sepsis on the initial day of capnography implementation.

Facilitators

The success of the implementation phase was attributed to the Straub Geriatric and Long Term care team and the SNF nursing staff. Healthcare providers were diligent to utilize the Capnography Guideline when assessing patients whose symptoms met the older adult modified SIRS criteria. The nursing staff was attentive in following the instructions for initiation and administration of capnography as well as notifying the HCP of the patient's change in condition. The collaboration between the team members and the stakeholders was evident and provided for the efficacious execution of this DNP project.

Utilization of the SNF's systems for data collection facilitated the application of this DNP project with uncomplicated navigation and data retrieval. The seamless system provided all team members access which assisted in proper documentation as well as expediting the evaluation of pre and post implementation data. This produced confidence in the results for the stakeholders.

Barriers

The major barrier to this DNP pilot project was the time constraint of one month for the implementation phase of the Capnography Guideline intervention. This hampered the project from obtaining a sufficient sample size. The lack of generated data from the limited SNF participant sample size was not adequate for the evaluation to determine the effectiveness of the intervention for the early identification of sepsis.

Summary

Chapter four reviewed the objectives and expanded on the sample narrative. This chapter discussed the trend analysis, outcome processes, project evolution, and the evaluation of this DNP project. Thus, completing the seventh step of the Iowa Model for Evidence-Based Practice.

CHAPTER 5. DISCUSSION

Interpretation of Findings

Due to the time constraint, small SNF sample size, and limited data, the effectiveness of the Capnography Guideline could not be fully determined. The findings from this DNP project supported capnography for the identification of suspected sepsis. However, there was no reduction in hospital admissions or length of stay.

An unexpected outcome was discovered during the implementation phase. Capnography was instrumental to Hospice conversations and referrals when $ETCO^2$ levels were utilized as a prognostic tool for mortality. This adds another important layer to care in the fragile SNF population. Further exploration is recommended in this area.

The expected outcomes were not realized due to the pilot's limitations, but the trend analysis and data supported capnography to identify sepsis. The T2 participants (age 77 and 86) who were referred to Hospice were admitted to the SNF with a diagnosis of sepsis. Although a diagnosis of sepsis was not rendered due to Hospice transfer, the $ETCO^2$ levels of both T2 participants suggested sepsis. The potential for capnography as a proxy for lactate to identify sepsis has been demonstrated and requires additional exploration to determine whether capnography can be effective in reducing hospital admissions and length of stay.

With the current data, the capnography intervention is not sustainable at the SNF of implementation. The Straub Geriatric Team and the DNP innovator have expressed the intention to broaden the scale of the project to expound the data collection time. A larger SNF sample size may generate the necessary data needed to determine the effectiveness of the Capnography Guideline.

Implications/Recommendations for DNP Essentials

The American Association of Colleges of Nursing enacted *The Essentials of Doctoral Education for Advanced Nursing Practice* in 2006. The DNP essentials define the core competencies expected and required for doctorate level nursing practice. Table 3 defines the fulfillment of the DNP essential related to this DNP project.

Table 3

EBP Project Fulfillment of DNP Essentials

DNP Essential	EBP Project Actualization
I. Scientific Underpinnings for Practice	• Utilized and implemented scientific knowledge and care practices to translate research into evidence-based practice for the enhancement of patient delivered care and evaluation of project outcomes • Formulated and analyzed innovative best practice methods
II. Organizational and Systems Leadership for QI & Economics	• Formulated best practice models for vulnerable patient populous • Evaluate financial feasibility and expenditures of project implementation • Effectuated exchange of information amongst stakeholders via diverse communication systems
III. Evidence-Based Practice/Translation Science	• Implemented systematic processes for the critical and analytical appraisal of literature to ascertain relevant evidence for best healthcare practices • Developed and analyzed systems of quality improvement procedures to ensure safe healthcare practices • Disseminated EBP results for the enhancement of patient care and outcomes
IV. Information Systems/Technology	• Implemented information systems and technology with protected collection and analysis of data according to HIPAA and privacy laws
V. Health Care Policy & Ethics	• Initiated and implemented EBP pilot project in consideration of health regulations and ethics for equitable healthcare treatment and privacy protection for patients and project participants
VI. Inter-professional Collaboration	• Employed healthcare informatics and communicative technologies to engage inter-professional collaboration for quality improvement of healthcare and patient outcomes
VII. Prevention and Population Health	• Developed population specific guideline and criteria for health promotion and disease prevention
VIII. Advanced Nursing Practice & Education	• Promoted nursing professionalism through exemplary standards of care via the execution of an evidence-based healthcare innovation to improve delivery of patient care and outcomes

Plans for Dissemination

The project results will be disseminated to the stakeholders via an electronic report and a formal presentation in March of 2018. These options will afford the stakeholders to view and participate in the findings as their schedule allows.

These findings and methods will be presented to the SNFs on O`ahu to demonstrate the potential impact of capnography among the older adult population. The results will provide an outline of project execution to future implementation sites to support SNF quality measures for the improvement of patient care and outcomes.

To facilitate awareness to the broader community, this project was presented in a poster presentation at the University of Hawai`i at Mānoa Interdisciplinary Poster Festival in April 2018. An abstract of the pilot will be submitted to an annual nursing conference in the Fall of 2018.

Summary

In conclusion, the final step to disseminate findings were outlined in this chapter in accordance with the DNP project model, The Iowa Model of Evidence-Based Practice. The definition and fulfillment of the DNP essentials were recorded in this chapter as well.

The Capnography Guideline with modified SIRS criteria for the atypical presentation of older adults identified sepsis, but did not meet the expected outcomes. Further projects are needed to demonstrate the effectiveness of capnography to reduce hospital admissions and length of stay.

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